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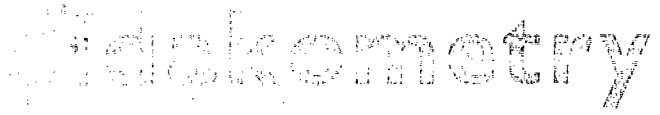
ABSTRACT

A framework is provided for the evaluation of self instructional materials before the materials are ready for field testing. Several aids are offered to assist the development of an evaluation model, including: checklists, maps of relations between terminal objectives and single didactic units, and unit charting protocols. Checklist questions cover the following areas: (1) goal relevance, (2) procedural instruction, (3) organization and sequence, (4) stimulus function of didactic units, (5) response function of didactic units, (6) integration of program, (7) motivation level of program, (8) program language, (9) external factors, and (10) relations between terminal objectives and single didactic objectives. Examples of various kinds of unit charting protocols also are provided. (EMH)



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MAPPING THE PHENO-STRUCTURE
OF [illegible] SPACE ENGLISH

[illegible] July 1964

basis of these data are the final and most important steps in the evaluation process, much time and work can usually be saved by a systematic examination of the programmed materials before the empirical test. Several aids for this systematic mapping process are described and discussed, including checklists, diagrams of the relations between terminal objectives and the single didactic units, and various kinds of unit-charting protocols.

It is by now generally recognized that the process of developing valuable self-instructional materials is a comprehensive and time-consuming undertaking. The actual writing is preceded by a pre-writing phase, in which detailed goal analyses, target population analyses, and situation analyses are supplemented by logical and psychological analyses of the subject matter structure. Similarly, the writing of the preliminary version is succeeded by a post-writing phase, in which repeated empirical try-outs are interspersed with revisions, until the behavioral goals initially specified are finally reached. Though this process will always be time-consuming, it is hoped that some time and work will be saved as the proportion of trial-and-error behavior of the programmer's gradually dimishes, at the same time as progress is being made within the scientific theory upon which didactic programming is based.

Even at the present stage of our knowledge, much time and work in the post-writing stage could often be saved by a more systematic examination of the programmed material before the empirical tests. The fact that the successive empirical try-out of the materials are the final and most important steps in the evaluation process does not mean, of course, that we have to rush into premature data collection with hastily produced and unpolished versions of the study material. While an arbitrary reading through of the material may be fairly inefficient, a systematic mapping of certain apparent characteristics of the material on the other hand, may be very fruitful. We might call this examination of apparent characteristics, the mapping of the "pheno-structure" of didactic sequences (as distinguished from the mapping of the "effect-structure" that might be carried out during the empirical try-outs later on).

In the present paper several aids for this mapping process will be described and discussed, including checklists, diagrams of the relations between terminal objectives and the single didactic units, and various kinds of unit-charting protocols. It is felt that the examination is considerably facilitated by summarizing aids of these kinds. The risk of forgetting some important aspect of the examination is diminished, and a long series of questions about the material is much easier to answer on the basis of a summarizing protocol than on the basis of the non-aided looking through of a long sequence of material, in which the different parts cannot be kept within the field of sight at the same time.

It should be stated from the beginning that many different types of aids are possible, of course, and that each programmer should design his working tools to suit his own needs. The descriptions in the following should therefore be looked upon only as illustrations of various possibilities.

Introductory terminological note: In this paper the term "didule" is used to refer to the didactic unit of a programmed material. One didule is thought of as the program's contribution to the basic unit of interaction between pupil and study material, covering as a rule three components: the informational component (termed "stimule"), the request for response (termed "respule"), and the feedback component (termed "corrule"). The English term "frame" has often been used in the same sense as the present term "didule". However,

ambiguous use of the term "frame" often leads to imprecise statements. In addition, "frame" tends to carry some additional undesirable connotation for many readers, limiting it, for instance, to something that can be given a small-size visual presentation (what can be seen through the tiny "window" of some of the most widely advertised teaching machines). For these and other reasons it would seem advisable to avoid the use of "frame".

1. Examination by means of check lists

The simplest way of systematizing the important questions that might be examined is probably to make up a fairly detailed list of questions to be answered for each self-instructional study material and to use this list for checking off systematically the answers for each separate part of the course material. An example of such a list of questions is given in Box 1. (It should perhaps be added that some of the questions in this list are such that only the author himself can give a definite answer. Nevertheless, it is often possible to make intelligent guesses in advance, and thereby to save many steps in the revision process.)

Box 1

Check list for program examination, preliminary use

1. Examination of goal relevance and content:

1.1 Does the program contain all that it should contain according to the initial goal statements?
1.2 Has all irrelevant material been eliminated? (Irrelevant materials are those items which neither are included by the goal statements nor fill any clear-cut conventional function as aids in the process of reaching these goals.)
1.3 Have all those points, according to the target population analysis, the students have already mastered, been eliminated?
1.4 Does the program avoid giving any single subject matter aspect a coverage that, according to the goal statements, could be considered unreasonably large or unreasonably small?
1.5 Has all changeable information been checked, so that the students are given maximally recent information?
1.6 In the judgement of subject-matter experts, is the content free from factual errors?

2. Examination of the "procedural instruction" of the program:

2.1 Are the "procedural instructions" of the program to the student (instructions about the ways of handling the material during the study etc.) complete, clear and easy to follow?
2.2 Is the student given a sufficient amount of training in the way of giving answers or handling the teaching machine in the beginning of the program (as well as in other places where perhaps a new answering technique is introduced)?

3. Examination of the organization and sequence of content:

3.1 Does the program try systematically to establish a connection between those experiences or concepts that the student already have in their repertoires and the new knowledge that is introduced?
3.2 Is the program constructed to use -- where this is possible and appropriate -- the sequential approaches that are usually referred to by phrases such as "from the simple to the complex", "from the easy to the difficult", "from the concrete to the abstract"?

3.3 Are there sufficient exercises for application and repetition?

3.4 Are the units with material for repetition adequately spaced (in the beginning sufficiently near the first presentation to make correct answers possible and after that with increasing and sufficient intervals to keep up retention over large enough periods of time)?

4. Examination of the stimulus-function of the single didules:

4.1 Have irrelevant and distracting details been removed, so that the attention of the student is clearly focused on the central part of the information of the didule?

4.2 Is the communication presented in a sufficiently life-like and concrete way? For instance, have pictures and supplementary demonstration materials been used where such aids can supply the intended information more effectively than verbal description?

4.3 Are the examples given sufficiently varied so that the student does not get a wrong and one-sided picture of the principle or concepts being treated?

4.4 Is the position of information appropriate, so that, for instance, important information has not been placed after the response request?

4.5 Have the prompting techniques used been sufficiently varied?

4.6 Has unnecessary prompting been avoided?

4.7 As a rule, has meaningful prompting (by means of logical induction, parallel exemplification etc.) been chosen where appropriate rather than unnecessary formal prompting of a kind that may distract the student's attention and divert it to unimportant aspects of the communication?

5. Examination of the respule-function of the single didules:

5.1 As a rule, can the questions be answered on the basis of the information that the student has received?

5.2 As a rule, have response requests been avoided that can be answered without understanding of the content of the didule (by formal-linguistic pattern completions etc.)?

5.3 Has the response request been designed so as to give a reasonable guarantee that the student has understood the essential communication of the particular didule? In other words: Are the response requests relevant to the aim of the particular didule (always assuming that each didule has a specifiable aim)?

5.4 Does the program activate varying types of response behavior (writing, drawing, calculating, comparing, etc.)?

5.5 Do the alternatives of a multiple-choice question represent all reasonable, non-trivial sources of misunderstanding? In other words: Is it difficult to think of typical student errors not included among the alternatives listed?

5.6 Are the alternatives in a multiple-choice question so designed that the student's choice is not a pseudo-choice (e.g., so that the incorrect alternatives are not clearly absurd or formally incongruent with the main question)?

5.7 Does the program request the student to give those types of answers that the terminal situation will demand from him (so that, for instance, the program does not merely train the student to recognize correct decisions, if in the terminal situation the student's ability spontaneously to make correct decisions is also going to be tested).

6. Examination of the integrative function of the program:

6.1 Is the student given an opportunity of applying concepts and principles, first presented stepwise, to problem-solving of a kind that forces him to activate and operate upon several concepts or principles at the same time?

6.2 Are integrating materials in the form of reference tables, reference diagrams, reference maps or reference texts utilized where appropriate?

6.3 Does the program help the student to obtain an adequate initial organization ("Gestalt in advance", "properly structured expectations") as well as an adequate final organization ("final Gestalt", e.g., by means of "properly structured reviews")?

6.4 If a programmed textbook is used, does the student get a table of contents outlining the broad scope and structure of the total contents?

6.5 Are there adequate indices that make it easy for the student afterwards to brush up his knowledge within specific areas of information, if he so desires?

7. Examination of the motivating function of the program:

7.1 Have the programmers tried to provide a sufficient degree of variation in the review items? In other words: Is rote repetition, as far as seems appropriate, replaced by review by variation?

7.2 Does the difficulty level of the program appear, throughout the program, to be so adapted to the particular student group under consideration that there is a fair probality that the student will be neither bored nor discouraged?

7.3 Have the examples and illustrations -- to the extent that seems possible -- been made interesting and relevant to the experiences and needs of the particular student groups?

7.4 Do the possibilities of individualization within the program (available branching arrangements) correspond closely enough to the results of the initial analyses of the target population, so that, for instance, students with considerable previous knowledge of the subject matter are not forced to go through the same material as students without any previous knowledge?

8. Examination of the external form of the program: Language

8.1 Do the level of vocabulary and the structure of sentences seem to be sufficiently well adapted to the linguistic habits of the particular student group so as not to be an unnecessary barrier to communication of the main contents?

8.2 Is the meaning of new terms defined or otherwise demonstrated clearly enough as soon as they are introduced?

8.3 Is the language of the program always clear and unambigous?

8.4 Does the language always have an optimal degree of precision as judged from the goal statements of the program (that is, neither with too low a degree of precision, including sloppy everyday terms where precision is needed, nor with an unnecessarily high degree of precision, such as various scientific distinctions not to be further utilized in the desired terminal behavior)?

8.5 Is the use of didule numbering, punctuation, abbreviation etc. both correct and consistent?

9. Examination of the external form of the program: Other aspects

9.1 Is the general lay-out of the program both educationally appropriate and economically defensible?

9.2 Is the typography sufficiently clear for the intended student group and also designed to emphasize things that should be emphasized?

9.3 Are illustrations of various kinds, both within the program proper and in possible appendices to be used as reference material so designed technically that they can be expected to result in the best possible communication effect?

2. Examination by means of "T - D diagrams" depicting the relation between terminal objectives and single didactic units

Even during the writing process, it may often happen that it makes the work easier to draw simple diagrams of the relation between the terminal objectives as codified in the goal statements on the one hand and the single didactic units (the didules) as appearing in the written program on the other. Very often the program writer arranges both the specific goal statements and the single didule texts on separate cards in a card catalogue. This means that the diagrammatic survey often takes the form of a series of relational diagrams, from which it is easy to see which didule cards (D_1, D_2, etc.) are related to each single terminal card (T_1, T_2, etc.). During the post-writing phase it is easy to examine, with the aid of diagrams of this kind, whether or not certain parts of the total goal structure has been given too large or too little attention in the program. Similarly, it might be easily seen whether or not enough attempts seem to have been made to reach an integrated structure of knowledge. Figure 1 shows an example of such a diagram. The numbers of terminal objectives and didules included in the figure (T- and D-numbers) refer to the program fragment in Box 2.

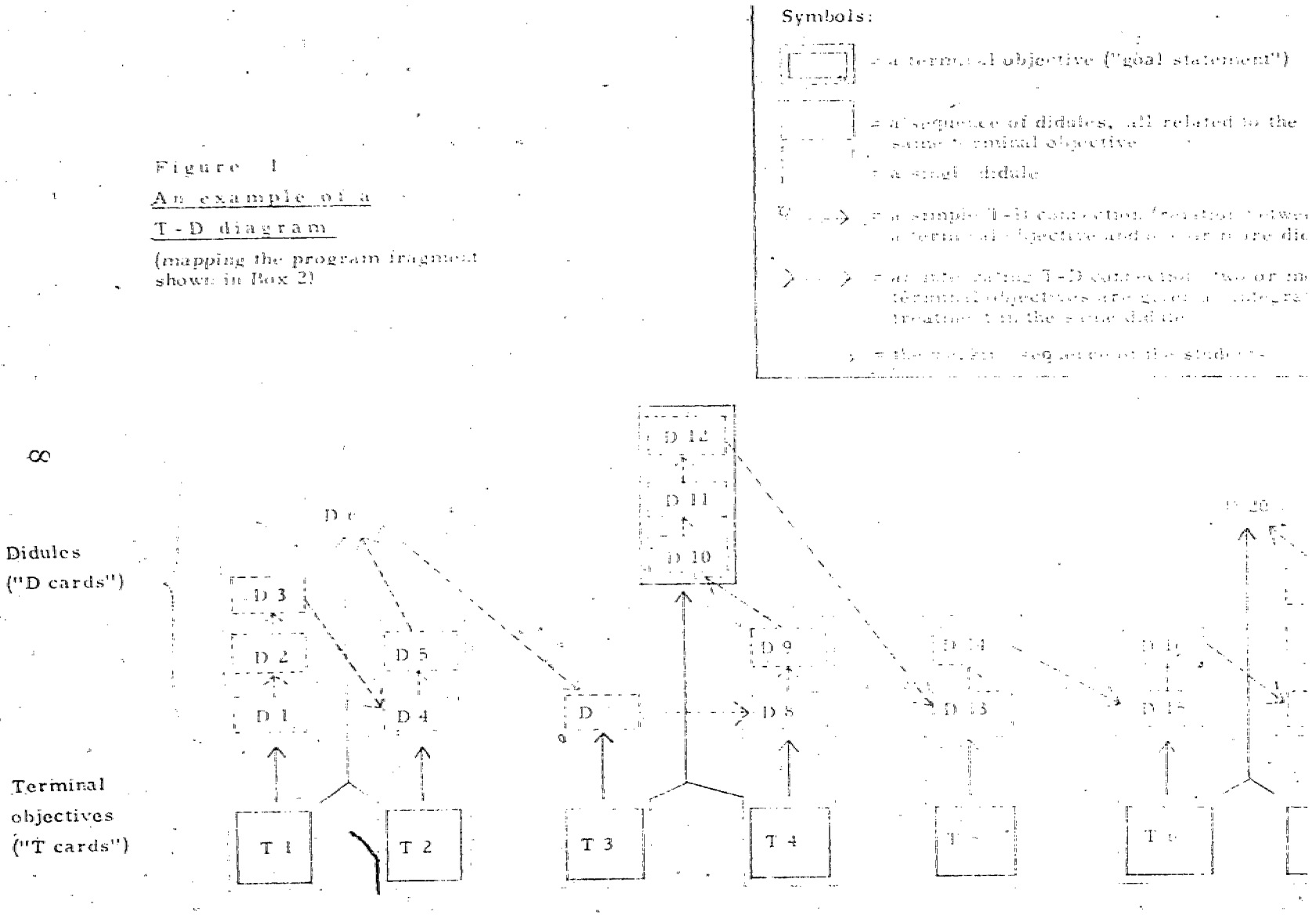
If we deal with a so-called scrambled book, the diagram should include not only information about the main part of any particular didule (the page with go-ahead signal and new information), but also information about the error-treatment pages (the pages that explain errors and refer the student back to the main pages again). As a rule, in these cases the programmer should also use a separate "pagination control list" for checking off page numbers used. The reason is, of course, that the programmer and the post-writing examiner has to keep an eye on the scrambling system, sometimes fairly complicated, in order to ensure a suitable sequence of pages, that is, a sequence which is educationally adequate as well as economical with respect to time and space. (No pages should be left empty; the pupil should not need to find his way through too long a process of page-turning each time; tasks that might make the answer easier than intended or that would otherwise interfere with each other should not be placed side by side on the same two-page fold-up of the book, etc.)

Figure 1

An example of a

T-D diagram

(mapping the program fragment shown in Box 2)



Box 2

Terminal descriptions (T cards) and didules (D cards) from a program for a course on programmed instruction (as supplemental material to the "Basic Design" in Figure 1)

Topic: Introductory course on programmed instruction

Subjects: Teacher students

Note: This (fragmentary) illustration contains 25 didules (D), covering 7 specific terminal objectives (T) -- following, in turn, on 3 fairly basic "principles".

T 1. The student should be able to give some acceptable reason for the emphasis on self-pacing in self-instructional materials.
(Principle 1)

T 2. The student should be able to recognize and recall the terms "self-pacing".
(Principle 1)

T 3. The student should be able to state some acceptable reason for the emphasis on "overt responses" in self-instructional materials.
(Principle 2)

T 4. The student should be able to recognize and recall the terms "overt response" and "covert response".
(Principle 2)

T 5. Given a set of instructional items, the student should be able to differentiate between items demanding "overt" and "covert" responses.
(Principle 2)

T 6. The student should be able to state some acceptable reason for the emphasis on low error-rate in self-instructional materials.
(Principle 3)

T 7. The student should be able to state some specific characteristics in self-instructional materials that make low error-rate possible, including, at least, the two notions of "small steps" and "careful sequencing".
(Principle 3)

D 1. In the classroom, the teacher most often works with the total class. If so, all pupils have to go forward at the same speed - for instance, at the speed of the average child. This rate often tends to make the work (more/less) interesting to the bright and quick-working child.
(Cf T 1) /less/

) 2. What would you guess about the effect on the slow learners of following the average pupil's speed?
Probably, they (will/will not) grasp enough of the material presented in the time allowed.

(Cf T 1) /will not/

) 3. If the slow learner does not grasp enough of the material presented, he will easily develop a(n) (positive/neutral/negative) attitude towards the classroom learning.

(Cf T 1) /negative/

) 4. Students working at their own speed are said to follow the principle of "self-pacing".
Apparently, the slow learner would be able to grasp more fully the material to be studied, if he were allowed to work at his own speed. Consequently, he would probably also develop a more positive attitude toward classroom learning, if the principle of _____ were used.

(Cf T 2) /self-pacing/

D 5. Since the quick learner is less likely to lose interest in the work (less likely to get bored), when allowed to proceed as quickly as he is able to, the principle of _____ also favors the bright and quick pupils.

(Cf T 2) /self-pacing/

D 6. To sum up, then, there is reason to believe that "teacher-pacing" is (more/less) likely to be a favorable learning condition than "_____".

(Cf T 1 & T 2) /less; self-pacing/

D 7. The student who actually works through a statistical calculation is (more/less) likely to learn effectively than a student who merely reads a description of what to do.

(Cf T 3) /more/

D 8. When a student learns, he may make both overt and covert responses. Those activities we can easily observe (like writing or manipulating a machine) we call overt responses. Those activities we cannot observe (like thinking) we call _____ responses.

(Cf T 4) /covert/

D 9. Using our technical terms "overt" and "covert" responses, we may say that the student of statistics who merely reads a discription of what to do, makes _____ responses to the text, whereas the student who works out the calculation in writing in addition shows _____ responses.

(Cf T 4) /covert; overt/

D 10. A house-wife who tries to learn cooking from a book just by reading may be said to make only _____ responses to the text. There is reason to believe that this is a (more/less) effective way of learning cooking than actual practice.

(Cf T 3 - T 4) /covert; less/

D 11. (Observable/Non-observable) reactions are, of course, a better guarantee that the student effectively responded to all the important aspects of the materials than are (overt/covert) reactions.

(Cf T 3 - T 4) /observable; covert/

D 12. In sum, then, covert responses are (more/less) likely to be effective in learning than are _____ responses.

(Cf T 3 - T 4) /less; overt/

D 13. Look back to the three sentences of item B above. In which sentence were you expected to make overt responses?
Answer: In the _____ sentence.

(Cf T 5) /third/

D 14. Look at the four items in the table below. Put an (x) in the list below to indicate the kind of response expected in each case from the student.

Item	Covert only	Overt
A		
B		
C		
D		

(Cf T 5) /Note. Panel I is excluded from the present illustration/.

D 15. A student who is anxious or uninterested in the work may not be motivated to continue working. A student who gets very many errors may get anxious or uninterested in the work. A student who gets very many errors, therefore, (is/is not) likely to be motivated to keep on working.

(Cf T 6) /is not/

D 16. If we make an error, we tend to remember the error, if it is not corrected. If we give a correct answer, we tend to remember the correct answer. In the first case we have to "unlearn" the error. In the second case we "learn" directly. Consequently, learning might become more efficient, if we could arrange the study material so that the students made (many/few) errors.

(Cf T 6) /few/

D 17. If the student is going to reach the goal we have set without making many errors, we have to arrange the study material in (small/large) steps.

(Cf T 7) /small/

D 18. If ITEM X is something the student needs to know before he can learn ITEM A and ITEM B, we should begin his sequence of items with ITEM _____.

(Cf T7) /X/

D 19. In order to make sure that the student gets few errors only, it would seem reasonable to recommend the use of _____ steps and a careful _____ of items.

(Cf T7) /small; sequence/

D 20. To sum up, if we use small steps and a careful sequence of items we are likely to get (more/fewer) errors. In that case motivation to keep on working will usually be (higher/lower) and the learning will proceed (more/less) efficiently.

(Cf T6 & T7) /fewer; higher; more/

3. Examination by means of didule protocols

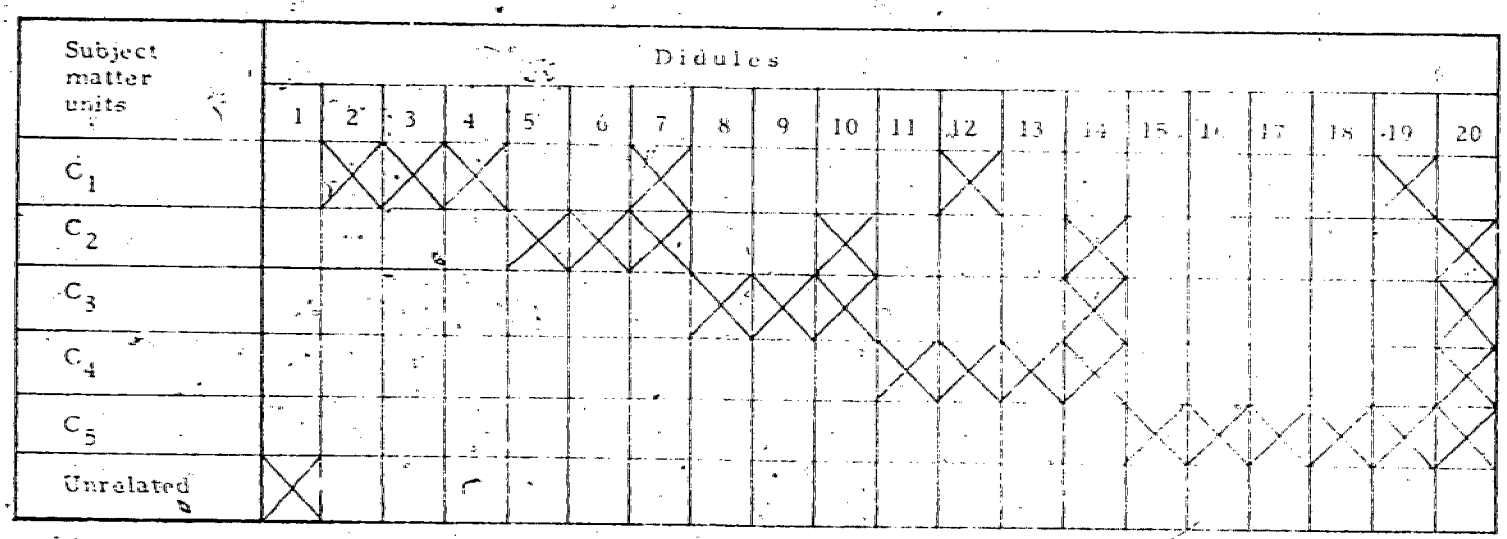
A didule protocol is a device which makes it easier to make the examination both complete and systematic. Examination by means of general checklists aids the examiner in covering many aspects, but it may not by itself help him to cover every single part of the program in a systematic way. As a rule a didule protocol includes, for each didule, a separate examination column, in which - depending on the particular aim - various kinds of questions may be answered when this particular didule is examined. Three general types of such protocols may perhaps be distinguished: subject matter protocols, methodological protocols, and combined protocols studying both subject matter distribution and the methodological approaches used.

(a) Subject matter protocol

The main aim of the subject matter protocol is to some extent similar to the aim of the T-D diagrams described above, viz. to facilitate the examination of the distribution of the subject matter over the didule sequence. A square-ruled paper may be a good starting-point. The numbers of the didules are written in numerical order along the top of the paper. The various subject matter units that are to be examined are listed down the left-hand margin. For instance, these units may be single conceptual units or conceptual relations which have been listed during the pre-writing phase as important key points to be covered in the program. Sometimes it is more natural to use psychological units than logical units, that is, to start out from a series of stimulus-response connections rather than from concepts and conceptual relations. Whatever the particular kind of units used, however, the general examination process will be similar. By means of some kind of check marks in the appropriate cells, we report in which of the didules a particular subject matter unit is treated (cf Figure 2).

Figure 2

An example of a subject matter protocol (didule protocol, type A)



Reading key: Subject matter unit C_1 is treated in didules 2, 3, 4 and later on also in didules 7, 12 and 19. Subject matter unit C_2 is treated in didules 5, 6, 7 and later on also in didules 10, 14 and 20. Etc.

Comments: The present example shows a subject matter distribution considered to be favorable. Only the introductory didule is unrelated to the subject matter to be covered. Each new subject matter unit is introduced through a number of didules in sequence and is later on repeated, first after a short interval, then after increasing intervals. The repetitions are at the same time arranged so as to include integration with other subject matter units.

Among the questions that may be answered with the aid of such a protocol, the following may be mentioned: (a) Is each single basic subject matter unit represented to a sufficient degree in the program? (b) Are some of the didules totally irrelevant to the main subject matter to be covered? (c) Is the treatment of the single subject matter units appropriately distributed (for instance, an intensive series of didules at the first presentation, followed later on by separate repetition items with gradually increasing intervals)? (d) To what extent have attempts been made to integrate the separate units into meaningful structures, and are these attempts made at optimal points in the sequence (for instance, where the separate concepts are sufficiently well treated and practised)?

When answering the last question, for instance, the examiner will study to what extent the same didule column contains check marks referring to several different subject matter units. It is usually desirable that this is the case in many didules in order to facilitate integrated structures of knowledge. At the same time the examiner of the program studies at what specific points in the didule sequence the new subject matter units are first presented. As a rule it is confusing to the student, if several new subject matter units are introduced in the same didule. An integrating didule therefore usually contains either a series of units introduced earlier in the program or, one new unit of subject matter in combination with one or more units introduced earlier.

It is sometimes maintained that integration of knowledge may be facilitated by specific patterns of didules, such as systematic alternation ("counterpoint"), systematic overlapping, chronological accumulation, or reversed accumulation of temporal behavior sequences. The advantage of the latter arrangement, for instance, may be that the pupil sometimes finds it strongly motivating to have the opportunity of going through the final phase early in his training as well as of seeing each training sequence lead up to a clear goal. When the final phase of the behavior sequence means a clearcut, perhaps dramatic demonstration of the goal attainment, this type of sequence may be of particular value. (This specific arrangement has often been explicitly recommended by the spokesmen for the so-called "mathetical approach", represented by Gilbert and his co-workers.) Further research is needed on these and other patterns of didules recommended for integration purposes. In this experimentation it is, of course, valuable to be able to examine, by means of subject matter protocols, the appearance of the various patterns under study. It is then easy for the examiner to observe inadvertencies and to correct arrangements which have been left in a less than optimal shape during the writing process. (A few examples of typical patterns referred to by the terms used above are given in Figure 3.)

(b) Methodological protocol

The purpose of the methodological protocols is to facilitate the examination of various methodological approaches and make it possible to answer systematically questions of the following types: (a) Has the programmer got stuck in certain working routines with the accompanying risk that the student finds the program monotonous? (b) Are the educational techniques used of such a kind that, besides facilitating the student's learning of certain subject matter facts, they also contribute to educationally desirable side-effects (such as good working habits, positive study attitudes, etc.)?

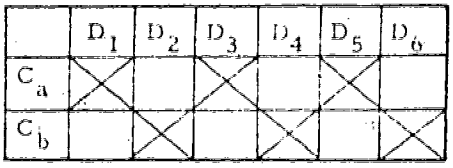
The protocol sheets will be similar to the ones used for subject matter protocols, that is, square-ruled papers with didule numbers along the top. However, questions about the educational approach or

Figure 3

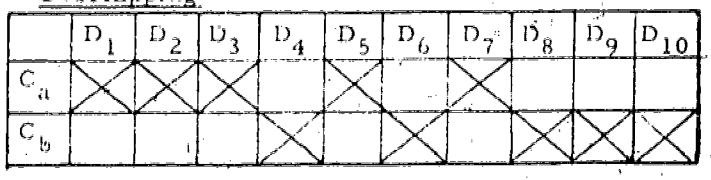
Examples of special types of didule sequences as mirrored in a subject matter protocol

Note: In this figure, numbers have been given to subject matter units that make up a connected temporal chain, whereas letters have been given to subject matter units that are not temporally related to each other. A small arrow below the didule number shows in which order different parts appear within a single didule.

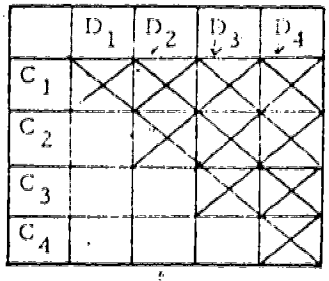
a. Systematic alternation ("counterpoint")



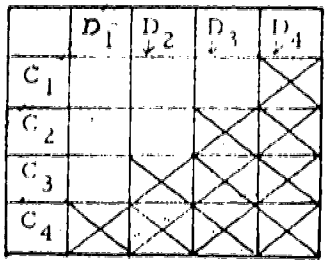
b. Overlapping



c. Chronological accumulation



d. Reversed accumulation



key-terms for different methodological categories (instead of subject matter units) are now written down the left-hand margin. If the question is answered by "yes" for a certain didule, the examiner puts a check mark in the appropriate cell (where the didule column and the row of the question intersect). Similarly, he inserts a check mark whenever the didule under study can be classified under the methodological category listed in the margin.

A very simple question that may be included for study in a protocol of this type is the following: Where has the student to go in order find a solution to the task set for him in the didule? Among the various possible sub-categories representing different groups of conceivable answers to this question, we may, for instance, mention the following:

(1) The solution can directly be found in the text of the same didule ("internal-explicit" source).
(2) The solution can be indirectly deduced (through a process of drawing conclusions etc.) from the new information that is given in the same didule ("internal-implicit" source).
(3) The solution can be found in the information presented earlier in the program ("external-proximal" source).
(4) The solution cannot be found within the program, but can be constructed in some way, usually with the aid of the student's background experience and/or his ability to use logical reasoning (or mathematical operations) ("external-distal" source).

At first sight, a subdivision of this type may seem to represent some kind of unnecessary and pedantic box-sorting eagerness. However, the observation of "response sources" is a very important part of the didule examination, and many existing programs would probably have looked quite different and been more effective, if the programmer had been made aware early enough of one-sided techniques utilized. The special terminological labels used ("internal-explicit" etc.) should not of course, be taken too seriously, but a brief and handy term may be useful in writing out these protocols as well as in discussing these phenomena.

Some of the sub-categories mentioned above can be further subdivided, if desirable. The third category, for instance, may be divided into maximally proximal cases (when the answer is to be found in the immediately preceding didule) and other cases (when the answer is found earlier in the program). Separate "appendices" (or "panels") as response sources can, when appropriate, be listed as a separate category, etc.

Such simple mapping gives the examiner quick information about the possible monotony of a sequence, showing, for instance, whether or not the programmer has used exclusively "internal-explicit" sources (which seems very often to be the case in some published programs). Each technique may serve an important function. The internal-explicit approach focuses the attention of the student on the key points in the present text and seems to be of particular value when new terms and concepts are introduced. The external-proximal method contributes to the gradual training of retention and may also be used in the process of integration. In order to ensure valuable educational side-effects (good working habits etc.), the programmer will probably often find it most profitable to use either an internal-implicit or an external-distal technique.

Other questions that can be studied in a similar way, are: What type of activity is expected from the student (for instance, copying, guessing, analogous exemplification, induction from own experiences, logical conclusions)? What kind of prompting is used? How is the answer related to earlier answers and to the key-points of the didule? What is the linguistic structure of the didule? (For instance, how high is the "density" of information-loaded words?) Etc. etc. (For further illustrations, cf Figure 4).

In certain cases it might be desirable to calculate some index score covering the "educational variation" (the distribution of didules with respect to a series of sub-categories related to a certain methodological question), or some index score covering the proportion of didules including certain educational features probably resulting in desirable side effects (when some of the sub-categories belonging to a certain methodological question are thought to be educationally more desirable than the other sub-groups). Such calculations should not, of course, be used too routinely, nor with too great a confidence in the exactness of the scores derived. Nevertheless, they can serve an important function as general warning signals, telling the examiner, in fact, "The program ought not to look like this. Revision urgently needed!" The methodological protocol can then show more exactly with which particular points this revision should deal.

(c) Combined protocols

Combined protocols register both subject matter distribution and particular methodological approaches in some kind of combination. In many cases it is not enough to see whether the subject matter is suitably divided over the didules, and whether the methods used are sufficiently varied. We also want to make sure that the various methods enter at the most appropriate points in the subject matter sequence. Sometimes we consider other methodological approaches adequate when a new concept is introduced than when the concept is already relatively well incorporated in the behavior repertoire of the student. The types of prompting techniques that we are perhaps reluctant to accept when we deal with a terminology that is well known to the student (for instance, prompting of a wholly formal-mechanistic type), we may sometimes find acceptable, or even natural, when we introduce a new term. In addition, we sometimes want to make sure that we do not connect a certain subject matter area too closely with a certain method in the student's behavioral repertoire. Not only do we want to have an overall methodological variation, but now and then we also have to check that we use a methodologically varied technique in the treatment of each single subject matter area.

In some respects, the combined protocols are very similar to the subject matter protocols: a square-ruled arrangement with didule numbers along the top and subject matter units listed down the left-hand margin. However, instead of the simple check-marking process, we now use a series of different symbols for various methodological categories (cf Figure 5).

A final note

It should be mentioned that protocols and diagrams of these types may often be good training instruments for persons wanting to train their ability to observe educationally important differences between various published programs. Hence, in courses about self-instructional materials and programming, protocols of these and similar types seem to be well suited to make the practical training of the study group more effective and efficient. However, the main aim of these protocols is, of course, to be an aid in the process of constructing a program, making the programmer or an independent examiner aware of possible faults in the program even before the first empirical try-out. As stated above, it is hoped that this will reduce the work and cost involved in the final phase of successive revision. As our scientific

Figure 4

An example of a methodological protocol (didule protocol, type B)

	didules									
Methodology:	1	2	3	4	5	6	7	8	9	10
1. Response sources:										
1.1 internal-explicit	X	X	X	X	X		X	X	X	
1.2 internal-implicit										
1.3 external-proximal						X				X
1.4 external-distal										
2. Types of prompting										
2.1 word-form prompts	X	X	X	X	X		X	X	X	
2.2 formal emphasis	X	X	X	X	X		X	X	X	
2.3 syntactic controls	X	X	X	X	X		X	X	X	
2.4 parallel exemplification										
2.5 induction from experience										
2.6 logical conclusion										

Reading key: In didule 1 the student can obtain the information needed for his answer directly from what is said within this didule ("internal-explicit" response source), and the answer is facilitated by strong formal prompting (word-form prompts, emphasizing the key words, and syntactic controls). Etc.

Comments: The example shows a one-sided use of "internal-explicit" response sources as well as formal prompting. In two cases, however, there is no prompting at all, but the student is expected to recall material from earlier didules (no. 6 and no. 10). In no case use is made of parallel exemplification, induction from experience, or logical conclusion. If the one-sidedness illustrated here continues over a larger material, there is the risk of both monotony and less adequate side-effects (lack of training in appropriate study techniques).

Figure 5

An example of a combined protocol (didule protocol, type C)

Subject matter units	Didules														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C_1		(W)	(M)	□				□			□				□
C_2					⌊	(I.)	□	□			□				□
C_3									(E)	(E)	□				□
C_4												⌊	(I.)	□	□
Unrel.	⊠														

Reading key:

Symbols for response sources:

- ○ = internal-explicit
- ◡ = internal-implicit
- □ = external-proximal
- ⌊ = external-distal

Symbols for prompting types:

- W = word-form prompts
- M = formal emphasis
- I = induction from experience
- L = logical conclusion
- E = parallel exemplification

The protocol is read in the following way: The subject matter unit C_1 is treated in the didules 2, 3, 4 and later on also in numbers 8, 11 and 15. In didules 2 and 3 the student obtains his answer within the same didule (first with the aid of word-form prompts, then with the aid of formal emphasis). In the other cases with C_1 the student has to rely on memory. Etc.

Comment:

The didule sequence seems to be well constructed. The micro sequences go from fairly easy tasks (with prompting) to more difficult ones (without prompting), non-formal prompting is frequently used, and the sequences contain problems that contribute to the integration of knowledge as final elements (number 8, 11 and 15).

knowledge of the self-instructional learning process is gradually increased, the questions studied by means of these checklists, diagrams and protocols will be more specific, and the evaluation will be more securely founded on hard facts. This will probably mean that the careful study of "pheno-structures" by means of aids of these kinds will gradually become more important and more cost-saving. The empirical try-outs with subsequent revisions will probably always remain an important final checking and polishing process, but the amount of work involved in it will decrease, and at the same time it will be possible and natural to pay increased attention to the post-writing, pre-testing examination.